BioRisk 17: 367–377 (2022)
doi: 10.3897/biorisk.17.77388
https://biorisk.pensoft.net

RESEARCH ARTICLE

A peer-reviewed open-access journal
BioRisk

Forests of Breznik municipality

Borislav Grigorov[1], Nikolay Velev[2], Assen Assenov[1], Momchil Nazarov[2], Beloslava Genova[3], Kiril Vassilev[2]

1 *Faculty of Geology and Geography, Department of Landscape Ecology and Environmental Protection, Sofia University "St. Kliment Ohridski", Sofia, Bulgaria* **2** *Institute of Biodiversity and Ecosystem Research, Department of Plant and Fungal Diversity and Resources, Bulgarian Academy of Sciences, Sofia, Bulgaria* **3** *Biological Faculty, University of Plovdiv "Paisii Hilendarski", Plovdiv, Bulgaria*

Corresponding author: Borislav Grigorov (borislav.g.grigorov@gmail.com)

Academic editor: Vlada Peneva | Received 31 October 2021 | Accepted 16 December 2021 | Published 21 April 2022

Citation: Grigorov B, Velev N, Assenov A, Nazarov M, Genova B, Vassilev K (2022) Forests of Breznik municipality. In: Chankova S, Peneva V, Metcheva R, Beltcheva M, Vassilev K, Radeva G, Danova K (Eds) Current trends of ecology. BioRisk 17: 367–377. https://doi.org/10.3897/biorisk.17.77388

Abstract

The current study aims to uncover the forest habitat diversity of Breznik municipality, following the EUNIS Classification. Initial data was collected from the Ministry of Environment and Water and the Forestry Management Plans. Forest habitat polygons were spatially processed with the use of the ArcGIS 10.8.1 software package. Field studies were performed to add more detailed information to the analysis. The phytocoenoses of the forest habitats are dominated by *Quercus dalechampii*, *Q. frainetto*, *Fagus sylvatica*, *Carpinus betulus.* Some artificial plantations with *Pinus nigra* and *P. sylvestris* were also present, as well as with non-native species, such as *Robinia pseudacacia* and *Quercus rubra.* The results of this study could be used for more in-depth research of the Breznik municipality vegetation.

Keywords

EUNIS, GIS, habitats, vegetation

Introduction

Forests are among the most important ecosystems for humanity, since they are key providers of many ecosystem goods and services. To a large extent, human well-being relies on forest ecosystems for the provision of food, clean water and air, pollination, genetic resources, erosion prevention, and to sustain biodiversity, etc. (MEA 2005;

TEEB 2010; Powell et al. 2013). Interacting with forests provides Forest Cultural Ecosystem Services which also helps in the improvement of human health and well-being (Dodev et al. 2020).

The study of forest ecosystem structure and function is important for understanding biodiversity–productivity relationships (Bohn and Huth 2017) and thus helps to cultivate the sustainable use of natural resources.

Forests in Bulgaria cover approx. 1/3 of its territory and provide about 85% of the water flow in the country (Raev et al. 2005; MOEW 2010). All Bulgarian forests are managed. According to their functions, forests are divided into three main types – forests for timber production, protective and recreation forests, and forests in protected areas (Stoeva et al. 2018). In 2010, the total area of protected native forests in Bulgaria was ca. 572 000 ha (FRA 2015).

Our current forest ecosystem knowledge at municipality level cannot adequately address any policymaker's needs for habitat monitoring and management. Only two papers were found dealing with the forest vegetation and reconstruction afforestation activities of Breznik municipality (Panova and Bondev 1985; Krastev 1990). The European Nature Information System (EUNIS) is an essential tool for implementing nature conservation activities like conducting habitat inventories, monitoring, and the management of protected areas, etc. (Chytrý et al. 2020). A habitat map will summarize the current distribution of forest habitat types in the municipality and will help in any ecological surveys and analysis.

The aim of this study is a complete investigation and mapping of forest habitats according to EUNIS classification on the territory of Breznik municipality.

Methods

Breznik municipality is located in the western part of the country. The territory falls mainly within 600–1000 m a.s.l. It covers an area of 404 km^2 and has diverse natural features, including the mountains of Zavalska, Lyubash, Viskyar, Erulska and Cherna Gora, as well as Breznik Valley. According to Zagorchev et al. (1990), the lithology includes conglomerates, sandstones, clays, marls, limestones, dolomitic limestones, dolomites, marls, shales and volcanics – hornblende andesites, trachyandesites, and andesitobasalts. Soils are predominantly Luvisols, Leptosols and Fluvisols, following Koinov et al. (1956). A part of the territory falls within the NATURA 2000 sites (Council Directive 92/43/EEC 1992) Lyubash BG0000624 (with 0.29 km^2) and Rebro BG0000314 (with 0.009 km^2).

One hundred and fifty relevés were collected in the field following the Braun-Blanquet approach (Braun-Blanquet 1965) and the vegetation type was verified with 135 field points additionally (Fig. 1) during the 2021 field season. Verification points present GPS coordinates of verified polygons. They are placed in the homogenous part of polygons. The GPS data was collected by Juno BS Trimble device. All the field data collected was laid over the most recent orthophoto images available. Mapping was

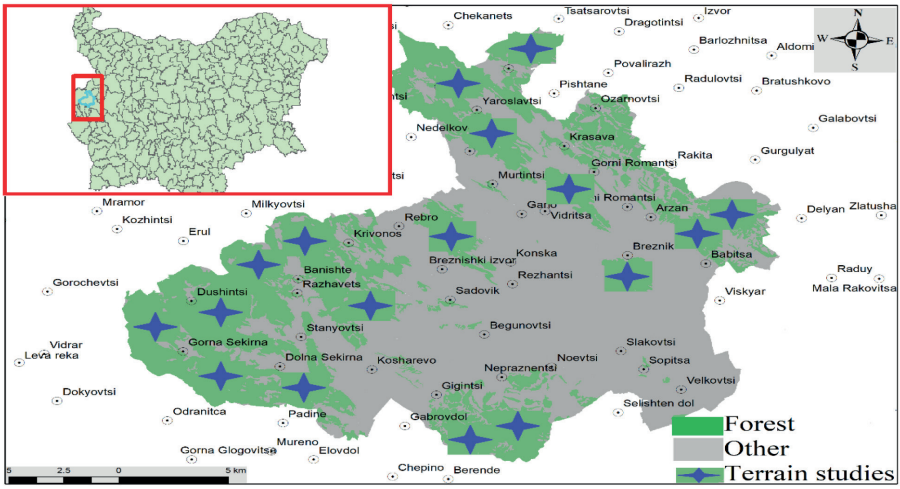

Figure 1. Field study in Breznik municipality. Each star marks 21 sample plots and verification points.

done using ArcGIS 10.8.1 software. The habitat map was created by polygon modifications, based on the available Forestry (from Forestry Management Plans), Habitat (from NATURA 2000 network in Bulgaria) and field survey data. The map scale was set at 1:5000. These modifications included merging, deletion, creation of new polygons and making changes in their boundaries.

The EUNIS habitat types were determined using the classification expert system EUNIS-ESy (Chytrý et al. 2020) integrated into JUICE 7.1 software (Tichý 2002). For all defined habitat groups were determined diagnostic, dominant and constant species following Chytrý et al. (2020). Every semi-natural habitat type was classified to alliance level according to Mucina et al. (2016). Associations were determined based on the expert knowledge and available literature sources for the country (Tzonev et al. 2006, 2019).

Results

All the studied forest types in Breznik municipality were related to 8 EUNIS habitat types. The EUNIS habitats map of the Breznik municipality is shown in Figure 2.

T1E *Carpinus* and *Quercus* mesic deciduous forest

Abiotic characteristic

This habitat type was widely distributed in the semi-mountainous areas of the municipality. It was found between 600 and 1000 m a.s.l. These forests were typically developed on northern and western slopes where the continental climatic conditions prevailed. Soils were averagely deep, Chromic Cambisols, Luvisols and Cambisols. The

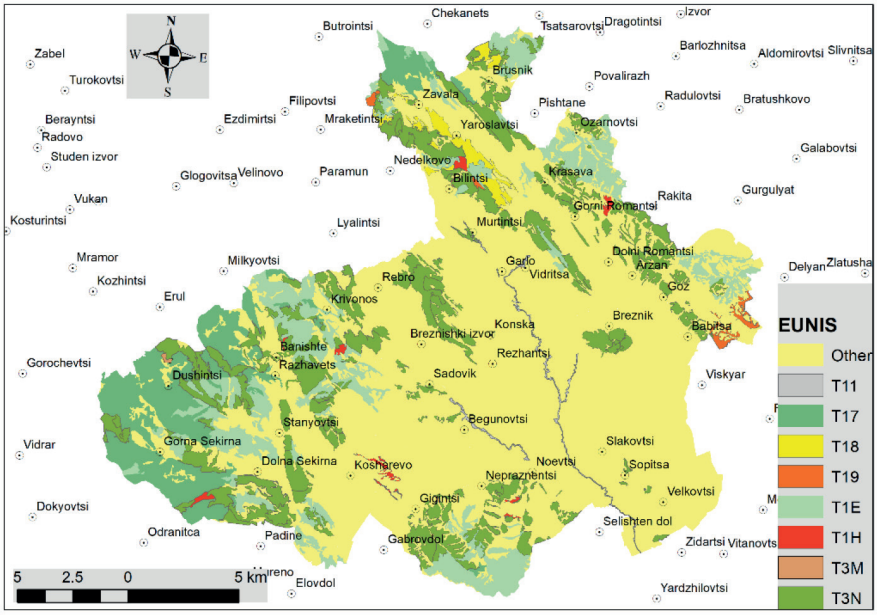

Figure 2. EUNIS forest habitat types in Breznik municipality.

bedrock types were from the magmatic, sedimentary and metamorphic rocks groups. This habitat type was presented by 60 polygons (map units) and covered a total area of 35.2 km^2. The polygon's area was in the range of 0.01–3.73 km^2.

Species composition and vegetation structure

Species-poor monodominant or mixed forests with a closed horizontal structure and total cover of 90–100%. The tree and shrub layers were well-developed. The herb layer was absent sometimes or present with a very low cover (5–8%). The tree layer was formed by *Carpinus betulus* or/and *Quercus petraea* agg. In the species composition, *F. sylvatica* was found in some stands with a cover of 20–30%. Other tree species were *Sorbus torminalis*, *S. aucuparia*, *Acer platanoides*, *Tilia platyphyllos*. The shrub layer was formed by the same species from the tree layer as well as *Chamaecytisus hirsutus*, *Ligustrum vulgare*, and *Corylus avellana*. The shrub layer had a cover of 10–50%. The herb layer was characterized by low species richness in the monodominant *C. betulus* forests and by a higher species richness in the mixed *Carpinus betulus-Quercus petreae* agg. and the monodominant *Q. petraea* agg. forests. The most frequent species in the herb layer were *Poa nemoralis*, *Festuca heterophylla*, *Luzula luzuloides*, *Melica uniflora*, *Mercurialis perennis*. These vegetation types were subjected to alliances Carpinion betuli and Fagion sylvaticae s.l., order Fagetalia sylvaticae and class Carpino-Fagetea.

T1H Broadleaved deciduous plantation of non-site native trees

Abiotic characteristic

This category had a scattered distribution. The terrains were slightly inclined (10–15°). These forests were planted in the last 50–70 years to stop erosion. Soils were shallow to moderately deep and the bedrock type was composed of volcanics, limestones, sandstones, and shales. This habitat type was presented by 11 polygons and covered a total area of 1.6 km^2. The polygon's area was in the range of 0.02–0.33 km^2.

Species composition and vegetation structure

These plantations were covered by the monodominant stands of *Robinia pseudoacacia* and *Quercus rubra*. The *Quercus rubra* stands especially have poor species composition. The total vegetation cover was 85–100%. Other common tree species found were *Quercus cerris*, *Q. frainetto*, *Q. petraea* agg. The shrub layer was formed from the same species mentioned above, accompanied by *Crataegus monogyna*, *Prunus cerasifera*, *L. vulgare*, *Cornus mas*, *Euonymus verrucosus*. The herb layer was characterized by poor species composition also, with the occurrence of *P. nemoralis*, *M. unuflora*, *F. heterophylla*, *Viola riviniana* agg. The *Robinia pseudoacacia* plantations were typical for eroded terrains and had a semi-open horizontal structure. These stands were formed by a low tree layer with a total cover of 80–90%. Other tree species found were *P. cerasifera*, *P. avium*, *Q. cerris*, *Q. frainetto*, *Q. petraea* agg. The shrub layer consisted of the same species, accompanied by *C. mas*, *Prunus spinosa*, *Rubus caesius*, *Rosa canina*, *C. monogyna*, *Clematis vitalba*, and *E. verrucosus*. It had coverage between 25 and 40%. The herb layer was well-developed and covered 80–100% for *R. pseudoacacia* forests and 50–65% for *Q. rubra* forests. In the *R. pseudoacacia* forests, *Bromus sterilis* was a dominant species and *Galium aparine* was subdominant. This vegetation was classified to association Bromo sterilis-Robinietum, alliance Balloto nigrae-Robinion pseudoacaciae, order Chelidonio-Robinietalia pseudoacaciae, class Robinietea.

T3M Coniferous plantation of non-site native trees

Abiotic characteristic

The artificial plantations dominated by *Pseudotsuga menziesii* were presented by just one polygon in Breznik municipality. The bedrock was composed of marls and shales. Soil type was Chromic Luvisols. The single locality of this habitat type covered an area of 0.11 km^2.

Species composition and vegetation structure

Species-poor plant community with a closed horizontal structure and canopy of 100%. The only dominant species in these stands was *Pseudotsuga menzeisii*. The strong shady

effect of the canopy limited the development of shrub and herb layers. In the shrub layer, some single individuals of *C. monogyna*, *R. caesius* and *Quercus* spp. were found. The herb layer barely covered 5–10% and was formed by the species *Geum urbanum*, *P. nemoralis*, *Aremonia agrimonoides*, *Veronica chamaedrys*, *M. uniflora*.

T3N *Coniferous plantation of site-native trees

Abiotic characteristic

This category was widely distributed in the northern, western, and southern parts of the municipality. It occurred on flat terrains and slopes (20–25°) with different expositions. These forests were planted in the 50–70s of the last century to battle erosion. The soils were shallow to averagely deep – Chromic Luvisols and Rendzic Leptosols. The bedrock was composed of magmatic, sedimentary, and metamorphic rocks. This habitat type was presented by 189 polygons and covered a total area of 64.9 km^2. The polygon's area was in the range of 0.003–2.91 km^2.

Species composition and vegetation structure

The artificial forests of *Pinus nigra* and *P. sylvestris* had a diverse species composition. The *Pinus sylvestris* forests had a closed horizontal structure with a well-developed tree layer. Other species found in this layer were *Q. petraea* agg., *Q. frainetto*, *Populus tremula*, *Acer pseudoplatanus*, *F. sylvatica*, *C. betulus*. Apart from these species, the shrub layer consisted of *R. caesius*, *R. canina*, *C. monogyna*, and *C. vitalba*. The herb layer had poor species composition and was presented by *G. urbanum*, *Aremonia agrimoides*, *P. nemoralis*, *Luzula luzulodies*, *F. heterophylla*, etc.

The artificial plantations of *P. nigra* were typical for eroded carbonate terrains with shallow soils. The latter ecological conditions were a barrier to the development of highly productive forests. The average tree height was 3–5 m. This vegetation type had a semi-open horizontal structure. Some polygons had experienced fires and intensive timber extraction. These places have turned into transitional woodland-shrub complexes. Typical species were *Q. cerris*, *Q. frainetto*, *Q. pubescens*, *Fraxinus ornus*, *C. mas*, *C. monogyna*, *P. spinosa*, *R. caesius*, *C. hirsutus* and *Carpinus orientalis*. The herb layer consisted mainly of *P. nemoralis*, *Dactylis glomerata*, *G. urbanum*, *Festuca dalmatica*, *M. uniflora*, *Buglossoides purpuleacea* and *Fragaria vesca*.

T11 Temperate *Salix* and *Populus* riparian forest

Abiotic characteristic

This habitat type was distributed along the riverbed of Konska River and its tributaries. Soils were averagely deep and the alluvial terraces were periodically flooded. This

vegetation was degraded, moreover, destroyed in some areas. The habitat type was presented by 9 polygons and covered a total area of 1.4 km^2. The polygon's area was in the range of 0.008–0.69 km^2.

Species composition and vegetation structure

Vegetation with a closed horizontal structure and a total cover of 95–100%. There were three well-developed layers. *Salix fragilis* and *Alnus glutinosa* were dominating the top one. Other common species were *P. tremula*, *R. pseudoacacia*, *Salix purpurea* and *C. betulus*. The shrub layer was formed by the same species, accompanied by *Cornus sanguinea*, *C. monogyna*, *P. spinosa*, *P. cerasifera*, *Rubus* spp., *C. vitalba*. The herb layer had different species richness along with the plots due to the tree layer shading effect. Common species were *Aegopodium podagraria*, *Ranunculus serbicus*, *Agrostis stolonifera* and *Lysimachia nummularia*. Invasive species, such as *R. pseudoacacia*, *Amorpha fruticosa*, *Erigeron annuus* and *Conyza canadensis* were typical as well.

T17 *Fagus* forest on non-acid soils

Abiotic characteristic

This habitat type was typical for the southwestern part of the study area. Terrains were slightly inclined (up to 10°) with variable exposition. Soils were shallow to moderately deep Cambisols. The bedrock types were limestones and dolomites. This habitat type was presented by 16 polygons and covered a total area of 32.3 km^2. The polygon's area was in the range of 0.1–19.55 km^2.

Species composition and vegetation structure

Species-rich communities with semi-open to closed horizontal structure and total cover of 85–100%. In the tree layer, the dominant species was *F. sylvatica*. Other tree species were *Q. petraea* agg., *C. betulus*, *S. aucuparia*, *S. torminalis*, *A. pseudoplatanus*, *Tilia cordata*. The shrub layer was well-developed and consisted of young trees from the aforementioned, as well as *C.monogyna*, *C. orientalis*, *Ulmus minor*, *L. vulgare*. The herb layer was species-rich and included some orchid species such as *Neotia nidus-avis*, *Dactylorhiza cordigera* and *Cephalantera longifolia*. This vegetation was classified to the alliance Cephalanthero-Fagion, order Fagetalia sylvaticae and class Carpino-Fagetea.

T18 *Fagus* forest on acid soils

Abiotic characteristic

This habitat was typical for the northwestern part of the territory, occurring in Viskyar Mountain from 600 to 1000 m a.s.l. The terrains were slightly inclined (up to 10°)

and the exposition was variable. The soils were shallow to moderately deep Cambisols. The bedrock types were magmatics and volcanics. This habitat type was presented by 9 polygons and covered a total area of 4.6 km^2. The polygon's area was in the range of 0.02–2.92 km^2.

Species composition and vegetation structure

Species-poor to moderately species-rich phytocoenoses with a closed horizontal structure and total cover 90–100%. There were three layers – tree, shrub and herb layers. The dominant species was *F. sylvatica*. The tree layer had a canopy of 75–100%. Other species found were *A. pseudoplatanus*, *Q. petraea* agg., *and C. betulus*. The shrub layer was formed by the same species from the tree layer as well as *Corylus avellana*, *Rubus hirtus*, *R. idaeus*. The herb layer within the stands with a high tree layer canopy (close to 100%) was patched and had low cover (5–15%). On the other hand, within stands that have been recently cut, the herb layer reached a cover of 30–70%. Species with higher cover and abundance found in the herb layer were *Galium odoratum*, *Festuca drymeja*, *Cardamine bulbifera*, *Lamiatsrum galeobdolon*. The cover of bryophytes was very low – about 2–5%. This vegetation was classified to associations Asperulo-Fagetum and Festuco drymejae-Fagetum, alliance Fagion sylvaticae s.l., order Fagetalia sylvaticae and class Carpino-Fagetea.

T19 Temperate and submediterranean thermophilous deciduous forest

Abiotic characteristic

This habitat type was widely distributed within the municipality's boundaries. It was found from 600 to 1000 m a.s.l. on flat and slightly inclined terrains up to 10°. The exposition was mainly eastern and southern. Soils were shallow to moderately deep with high skeletal composition, dry during the summer period. The main bedrock types were silicates and limestones. This habitat type was presented by 27 polygons and covered a total area of 7.5 km^2. The polygon's area was in the range of 0.008–0.76 km^2.

Species composition and vegetation structure

The vegetation had a semi-open to closed horizontal structure. The vertical structure consisted of 3 or 4 well-formed layers. There were tree, shrub, and herb layers, and in some stands, a separate layer formed by bryophytes and lichens above the ground. The tree layer had a canopy of 75–90% and dominant species were *Q. cerris*, *Q. frainetto* and *Q. pubescens*. In general, these tree species were codominant and formed mixed forests but some monodominant stands were found also. Other tree species were *F. ornus*, *Acer campestre*, *C. orientalis* and *S. torminalis*. The shrub layer had a cover between 10 and 60% and was formed by the same species found in the tree layer, as well as *C. monogyna*, *R. canina*, *P. spinosa*, *Euonymus europaeus*, *E. verrucosus*, *C. vitalba* and *Acer tataricum*. These communities had a well-developed and species-rich herb layer with highly abundant species such as

P. nemoralis, *F. heterophylla*, *Galium pseudoaristatum*, *M. uniflora*, *D. glomerata*, *Buglossoides purpurocaerulea*. The cover of bryophytes and lichens was mainly in the range of 5–15%. These vegetation types were subjected to alliances Quercion confertae and Quercion petraeo-cerridis, order Quercetalia pubescenti-petreae and class Quercetea pubescenti.

Discussion

The present research is among the few in the country that offer a map of all forest habitats in a single municipality on such a broad scale (1:5000). According to the EUNIS classification, a total of eight habitat types were established and mapped in Breznik municipality. They were presented by 322 polygons and covered a total area of 147.51 km^2. Forest ecosystem mapping is an essential part of the modeling and assessment of ecosystem condition and services (Glushkova et al. 2020).

The widest-spread forest habitat type in this municipality is the Coniferous plantation of site-native trees (T3N) covering an area of 64.9 km^2. It is followed by the *Carpinus* and *Quercus* mesic deciduous forest (T1E) with an area of 35.2 km^2, and the *Fagus* forest on non-acid soils (T17) with an area of 32.3 km^2. The least common forest in the municipality is the artificial plantation of *P. menziesii*. The artificial plantations occupy ca. 45% of the total forest area in the municipality. These forests come as a result of the intensive afforestation activities implemented during the 60–80s of the last century. Large areas of the native forests have been cleared in the past for pastures and have been used as such for decades. These activities have led to the development of soil erosion, especially in areas with shallow ones. Panova and Bondev (1985) also pointed out the large extent of forest destruction and that only remnants of natural forests exist on the eastern part of Viskyar Mountain. Nowadays, semi-natural forests are well-preserved in the southwestern part of the municipality where slopes are steep. Dominant species are *F. sylvatica*, *Q. cerris*, *Q. frainetto*, *Q. petraea* agg. and *C. betulus*. The *Quercus pubescens* forests have a restricted distribution on places primarily with southern and eastern expositions and higher solar insolation received.

Fieldwork observations in 2021 found that most of the forest habitats in the municipality are affected by negative processes and phenomena, and thus are not in a favorable condition. This is a direct result of human activities – cutting, afforestation with non-native and invasive species (*P. menziesii*, *R. pseudoacacia*) and pollution. Fires are common as well. There are natural events that also have a negative impact: erosion, pests and climate change, leading to droughts. Combined, the aforementioned processes change the structure and species composition of the natural forests. For instance, xerothermic oak forests are turning into shrublands or are mixing with *Pinus nigra*. Riverine forests of *S. fragilis* are damaged almost everywhere.

There is an urgent need to adopt measures to sustain natural forest regeneration. Plans and practices of the foresters have to be updated in order to reduce the pressure on forests, and curb forest degradation and species richness loss (Krastev 1990; Vacik et al. 2009; Zlatanov and Lexer 2009). Afforestation with non-native species has to be switched to native ones and the introduction of invasive species has to be halted.

Conclusions

The forest habitats of Breznik municipality are presented by 8 habitat types according to the EUNIS classification. Some 45.6% of the forests are artificial plantations, including non-native and invasive species. The latter also provide ecosystem services, such as pollination potential as being suitable habitats for wild pollinator insects – e.g. the stands of honey plant *R. pseudoacacia*.

The intensive and prolonged anthropogenic pressure like deforestation has led to the formation of coppice forests in some areas. Other forests have been intensively exploited for the last 30–40 years and turned into shrublands with pastures. On the whole, the forests in Breznik municipality could be evaluated as being in an unfavorable condition.

Acknowledgements

This investigation was carried out with the financial help of the NSP "Young scientists and postdoctoral students, 2021".

References

Bohn F, Huth A (2017) The importance of forest structure to biodiversity–productivity relationships. Royal Society Open Science 4(1): e160521. https://doi.org/10.1098/rsos.160521

Braun-Blanquet J (1965) Plant sociology: The study of plant communities. Hafner, London, 439 pp.

Chytrý M, Tichý L, Hennekens S, Knollová I, Janssen J, Rodwell J, Peterka T, Marcenò C, et al. (2020) EUNIS Habitat Classification: Expert system, characteristic species combinations and distribution maps of European habitats. Applied Vegetation Science 23(4): 648–675. https://doi.org/10.1111/avsc.12519

Council Directive 92/43/EEC (1992) on the conservation of natural habitats and of wild fauna and flora. http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm

Dodev Y, Zhiyanski M, Glushkova M, Shin W (2020) Forest welfare services-the missing link between forest policy and management in the EU. Forest Policy and Economics 118: e102249. https://doi.org/10.1016/j.forpol.2020.102249

FRA [Global Forest Resources Assessment] (2015) Country report. Bulgaria.

Glushkova M, Zhiyanski M, Nedkov S, Yaneva R, Stoeva L (2020) Ecosystem services from mountain forest ecosystems: Conceptual framework, approach and challenges. Silva Balcanica 21(1): 47–68. https://doi.org/10.3897/silvabalcanica.21.e54628

Koinov V, Trashliev H, Yolevski M, Andonov T, Ninov N, Hadjiyanakiev A, Angelov E, Boyadjiev T, Fotakieva E, Krastanov S, Stainkov I (1956) Soil map of Bulgaria (Scale 1:400 000). Sofia, GUGK, Kartproekt. [In Bulgarian]

Krastev T (1990) Problems in reconstructions in FE – Breznik. Forest Economy 2: 11–15. [In Bulgarian]

MEA [Millennium Ecosystem Assessment] (2005) Ecosystems and human well-being: Synthesis. Island Press, Washington D.C., 138 pp.

MOEW [Ministry of Environment and Water] (2010) Fifth National Communication on Climate Change under the United Nations Framework Convention on Climate Change, 169 pp.

Mucina L, Bültmann H, Dierßen K, Theurillat J-P, Raus T, Čarni A, Šumberová K, Willner W, Dengler J, Gavilán García R, Chytrý M, Hájek M, Di Pietro R, Iakushenko D, Pallas J, Daniëls FJA, Bergmeier E, Santos Guerra A, Ermakov N, Valachovič M, Schaminée JHJ, Lysenko T, Didukh YP, Pignatti S, Rodwell JS, Capelo J, Weber HE, Solomeshch A, Dimopoulos P, Aguiar C, Freitag H, Hennekens SM, Tichý L (2016) Vegetation of Europe: Hierarchical floristic classification system of vascular plant, bryophyte, lichen, and algal communities. Applied Vegetation Science 19: 3–264. https://doi.org/10.1111/avsc.12257

Panova E, Bondev I (1985) Vegetation in the eastern part of Viskyar Mountain National Student Conference, SU, BF, 23–29. [In Bulgarian]

Powell B, Ickowitz A, McMullin S, Jamnadass R, Padoch C, Pinedo-Vasquez M, Sunderland T (2013) The Role of Forests, Trees and Wild Biodiversity for Nutrition-Sensitive Food Systems and Landscapes Second International Conference on Nutrition Better nutrition better lives. FAO and WHO.

Raev I, Rosnev B, Alexandrov A, Popov E, Popov G, Lubenov T, Tsakov H, Mirchev P, Glushkova M, Vasilev Z, Spiridonov G, Smidt J, Fanta J, Maes B, Veen P (2005) Virgin forests of Bulgaria – inventory and strategy for sustainable management and protection of virgin forests. FRI-BAS – KNNV.

Stoeva L, Markoff I, Zhiyanski M (2018) National Forestry Accounting Plan of Bulgaria, including Forest Reference Levels for the period 2021–2025. MOEW.

TEEB [The Economics of Ecosystems and Biodiversity] (2010) Mainstreaming the economics of nature: A synthesis of the approach, conclusions and recommendations of TEEB. Progress Press, Malta, 36 pp.

Tichý L (2002) JUICE, software for vegetation classification. Journal of Vegetation Science 13(3): 451–453. https://doi.org/10.1111/j.1654-1103.2002.tb02069.x

Tzonev R, Dimitrov M, Chytrý M, Roussakova V, Dimova D, Gussev C, Pavlov D, Vulchev V, Vitkova A, Gogushev G, Nikolov I, Borisova D, Ganeva A (2006) Beech forest communities in Bulgaria. Phytocoenologia 36(2): 247–279. https://doi.org/10.1127/0340-269X/2006/0036-0247

Tzonev R, Dimitrov M, Gussev C, Pachedjieva K, Gogushev G, Apostolova-Stoyanova N, Nikolov I, Alexandrova A, Glogov P (2019) Phytosociological classification of the thermophilous oak forests in Bulgaria: New interpretation and gaps in knowledge. Phytocoenologia 49(4): 369–391. https://doi.org/10.1127/phyto/2019/0296

Vacik H, Zlatanov T, Trajkov P, Dekanic S, Lexer MJ (2009) Role of coppice forests in maintaining forest biodiversity. Silva Balcanica 10(1): 35–45.

Zagorchev I, Kostadinov V, Chunev D, Dimitrova R, Sapunov I, Chumachenko P, Yanev S (1990) Geological map of Bulgaria on Scale 1:100 000. Map sheet Vlasonitse and Breznik. Sofia, Committee of Geology and Mineral Resources. [In Bulgarian]

Zlatanov T, Lexer M J (2009) Coppice forestry in South-Eastern Europe. Problems and future prospects Silva 10(1): 5–8.